

WHAT IS CLAIMED IS:

1. An electromagnetic actuator comprising:
a housing defining a cavity therein;
5 a solenoid coil disposed in the cavity of the housing;
an armature disposed substantially coaxially with the solenoid coil, wherein
the armature can move between a first position proximate a portion of the housing and a
second position distal of the portion of the housing, in the second position the armature and
the portion of the housing define a first gap therebetween; and
10 an extension member extending in an axial direction into the first gap and
defining a second gap, the width of the second gap being less than the width of the first
gap.
2. The electromagnetic actuator as recited in claim 1, wherein the
15 extension member extends from the armature into the first gap.
3. The electromagnetic actuator as recited in claim 2, wherein the
housing comprises a recess that receives the extension member in the first position.
- 20 4. The electromagnetic actuator as recited in claim 1, wherein the
extension member extends from the housing into the first gap.
5. The electromagnetic actuator as recited in claim 4, wherein the

armature comprises a recess that receives the extension member in the first position.

6. An electromagnetic actuator comprising:

a housing comprising a body and an extension member having an inner

5 surface;

a solenoid coil disposed in the housing;

a shaft disposed substantially coaxially with the solenoid coil; and

an armature having an outer surface, the armature coupled to the shaft,

wherein the shaft and armature can move between a first position proximate the solenoid
10 coil and a second position distal of the solenoid coil, in the second position the armature
and the body of the housing define a first gap therebetween, the extension member
extending in an axial direction towards the armature and beyond the solenoid coil such that
the inner surface of the extension member and the outer surface of the armature define a
second gap therebetween, the width of the second gap being less than the width of the first
15 gap.

7. The electromagnetic actuator as recited in claim 6, wherein the

housing does not enclose the armature.

20 8. The electromagnetic actuator as recited in claim 6, wherein the
housing is substantially annularly shaped.

9. The electromagnetic actuator as recited in claim 8, wherein the inner surface of the extension member is substantially annularly shaped.

10. The electromagnetic actuator as recited in claim 8, wherein the solenoid coil is disposed substantially coaxially in the housing.

11. The electromagnetic actuator as recited in claim 9, wherein the armature is substantially annularly shaped.

12. The electromagnetic actuator as recited in claim 11, wherein the outer surface of the armature is substantially annularly shaped.

13. The electromagnetic actuator as recited in claim 12, wherein the armature is disposed substantially coaxial with the solenoid coil.

14. The electromagnetic actuator as recited in claim 12, wherein the second gap between the extension member and the armature is substantially annularly shaped.

15. The electromagnetic actuator as recited in claim 6, wherein the inner surface of the extension member and the outer surface of the armature are substantially parallel such that the second gap width between the extension member and

the armature is substantially constant.

16. The electromagnetic actuator as recited in claim 6, wherein the inner surface of the extension member and the outer surface of the armature are not parallel
 5 such that the second gap width between the extension member and the armature increases with increasing distance from the solenoid.

17. The electromagnetic actuator as recited in claim 6, wherein the inner surface of the extension member and the outer surface of the armature are not parallel
 10 such that the second gap width between the extension member and the armature decreases with increasing distance from the solenoid.

18. The electromagnetic actuator as recited in claim 6, wherein the shaft comprises a shaft collar on an end of the shaft, the shaft collar limiting shaft travel in an
 15 axial direction.

19. The electromagnetic actuator as recited in claim 6, wherein the shaft comprises threads.

20. The electromagnetic actuator as recited in claim 9, wherein the shaft comprises a threaded nut engaged with the shaft threads, the threaded nut securing the armature to the shaft.

21. The electromagnetic actuator as recited in claim 6, wherein the armature has an annular recess for receiving a spring.

5 22. The electromagnetic actuator as recited in claim 6, wherein the armature has a passage and a portion of the shaft is disposed in the passage.

23. The electromagnetic actuator as recited in claim 6, further comprising a spring that biases the armature away from the solenoid.

10 24. The electromagnetic actuator as recited in claim 6, further comprising a permanent magnet disposed in the housing, wherein the permanent magnet biases the armature towards the solenoid.

15 25. The electromagnetic actuator as recited in claim 24, wherein the permanent magnet is substantially annularly shaped.

26. The electromagnetic actuator as recited in claim 6, further comprising a core disposed in the housing.

20 27. The electromagnetic actuator as recited in claim 6, further comprising a cylindrical bushing disposed in the housing and a portion of the shaft is

disposed in the bushing.

28. The electromagnetic actuator as recited in claim 6, further comprising a clamp plate disposed on the housing, wherein the extension member extends
- 5 in an axial direction towards the armature and beyond the clamp plate.